



# **NRC Readiness for Advanced Reactors**

## **Licensing – Materials and Component Integrity Research**

**Advanced Non-Light Water Reactors –  
Materials and Component Integrity  
Workshop**

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**December 9, 2019**

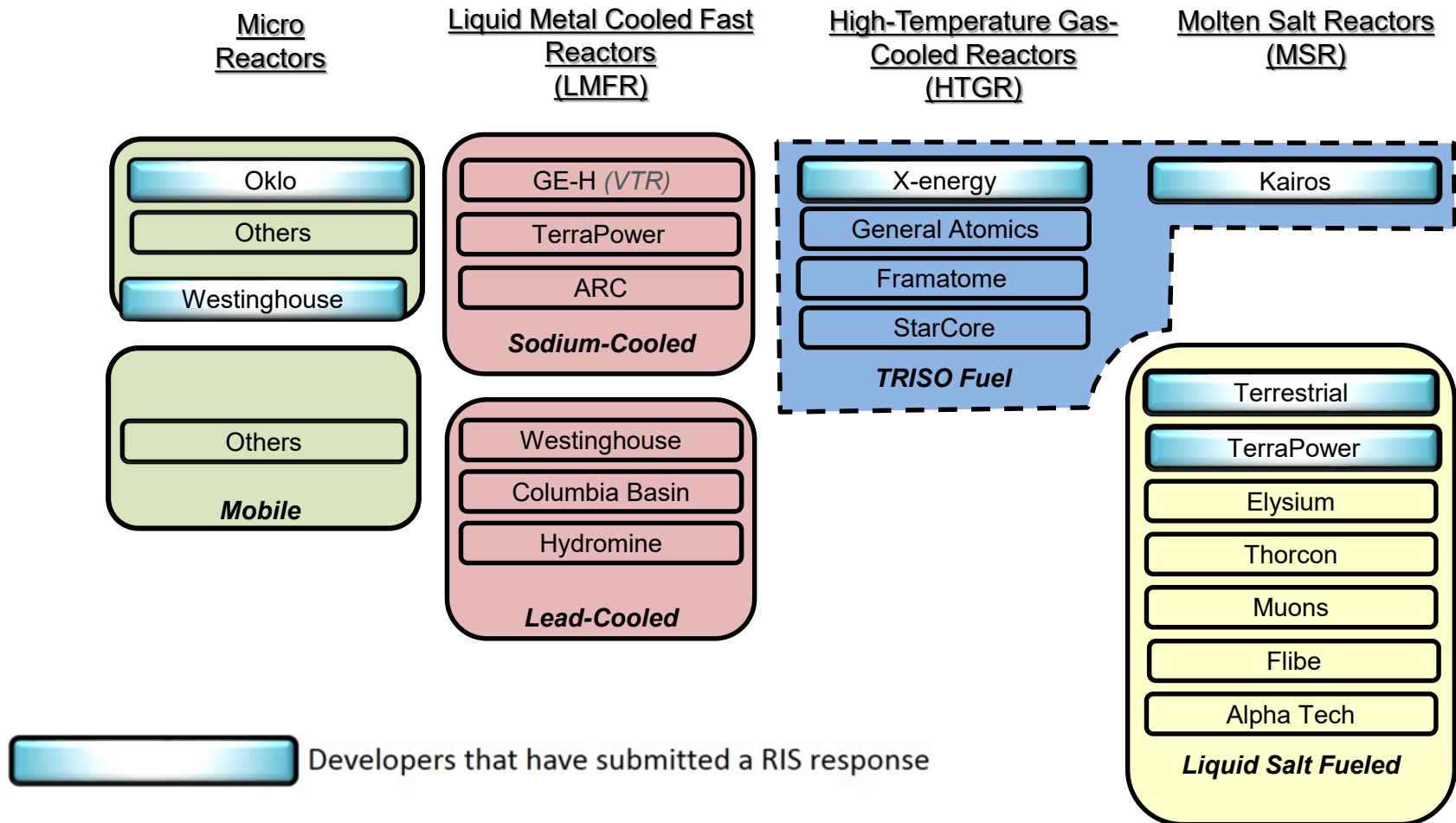


## **Disclaimer**

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# Advanced Reactor Landscape



# **Framework for Rightsizing Regulatory Processes**

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- ❖ **NRC's Policy Statement on the Regulation of Advanced Reactors**
  - Identifies desired characteristics of advanced reactors (enhanced margins of safety; use of simplified, inherent, passive, or other innovative means to achieve safety)
  - Address implications for safety and regulatory processes
- ❖ **Developer Goals – Meet the Advanced Reactor Policy Statement through innovation**
- ❖ **Regulatory processes should assure safety and provide predictability, and not be a barrier to innovation**

# **Framework for Rightsizing Regulatory Processes**

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## **Principles of Good Regulation**

❖ **Independence**

❖ **Openness**

❖ **Efficiency**

❖ **Clarity**

❖ **Reliability**

# **Framework for Rightsizing Regulatory Processes**

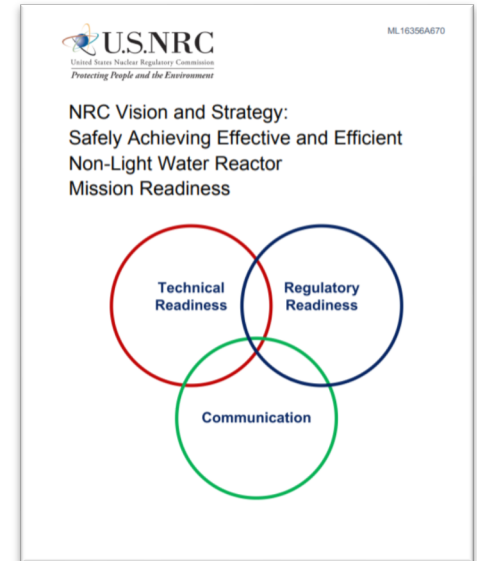
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## **Modern Risk-informed Regulator**

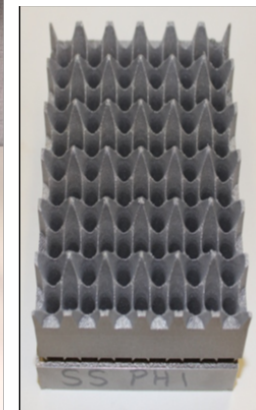
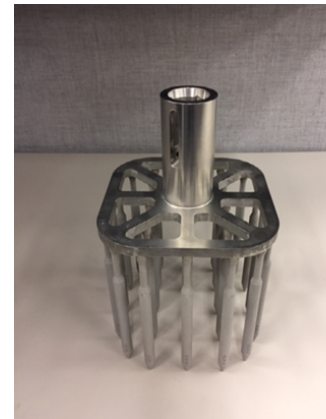
- ❖ **Accepting Risk in Decision Making**
- ❖ **Utilizing Technology**
- ❖ **Innovating how we work**
- ❖ **Attracting and Retaining Talent**

# Readiness for Advanced Reactors and Tomorrow's Technologies

- Staff knowledge and capacity
- Analytical capability
- Modern licensing approaches for advanced reactor design
- Consensus codes and standards
- Technology inclusive mindset
- International and domestic collaborations



Strategy Document on Non-light  
Water Reactor Readiness



Thimble Plugging Device

# **Advanced Reactors: Materials/Component Integrity**

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## Goal:

- ❖ Assess performance needs and issues for materials/component integrity
- ❖ Support development of a regulatory framework

## Approach:

- ❖ International Operating Experience
- ❖ Technical issues identification and resolution
- ❖ Flexible approaches to material qualification
- ❖ Coordination with DOE, EPRI, and International Counterparts



# **Advanced Reactors: Materials/Component Integrity**

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## **❖ Recent NRC Reports:**

- International operational experience with SFRs and HTGRs, focused on materials and component integrity (ADAMS ML18353B121)
- “Technical Gap Assessment for Materials and Component Integrity Issues for Molten Salt Reactors (ADAMS ML19077A137)

## **❖ Ongoing Activities:**

- ❖ Potential endorsement of ASME Section III Div. 5
- ❖ Graphite: source dependency of properties; molten salt intrusion/infiltration
- ❖ Evaluation of creep and prevention of creep failures of structural alloys
- ❖ High temperature corrosion (HTGR, SFR) and molten salt corrosion of structural alloys (MSR)
- ❖ Molten salt purity, redox control, and standards for corrosion experiments

# Graphite

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- ❖ Graphite is a material that presents a number of unique design considerations for ANLWRs (Contract support Numark Associates Inc)
  - ❖ Assess graphite design criteria in ASME Section III, Division 5 Code rules
  - ❖ Assess graphite properties and degradation including source dependency
    - Review experimental data and operational experience relevant to the performance of graphite
    - Perform a gap analysis on standards, regulatory guidance, and test procedures for evaluating graphite properties and degradation

# Creep and Creep-Fatigue

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- ❖ Creep-induced cracking and creep-fatigue are potential life-limiting factors for components in high-temperature reactors (contract support: ANL)
  - ❖ Survey to identify gaps in current creep and creep-fatigue design procedures in ASME Code and other codes
  - ❖ Develop post-processing tools to aid in executing the ASME Section III, Division 5 Code rules
    - Take FEA input and compare with code rules

# **High Temperature Corrosion / Molten Salt Compatibility**

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- ❖ Molten Salt Compatibility of Structural Materials and Graphite
- ❖ High Temperature Corrosion/Erosion/Oxidation of Structural Materials
- ❖ Assessment of Applicability of Existing Regulatory Guides and Standards Endorsed by Regulatory Guidance to Liquid-Fueled MSR
- ❖ Planned Reports:
  - ❖ Recommendations for molten salt corrosion testing/test plan
  - ❖ Recommendations for high temperature corrosion/oxidation
  - ❖ Summary of technical and regulatory gaps on molten salt chemistry

# **Technical Challenges/Opportunities**

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- ❖ High Temperature Materials Aging and Degradation
  - ❖ Radiation; Corrosion; Mechanical
  - ❖ Reactor Surveillance Programs; Accelerated Testing
- ❖ Welding and Joining
- ❖ Additive/Advanced Manufacturing
- ❖ Probabilistic Fracture Mechanics of Graphitic Components
- ❖ Materials Performance in Realistic Environments
- ❖ Lead-time for Materials Characterization & Qualification
- ❖ Development of New Materials - High-Entropy Alloys

# **Forging The Future**

## **Connect, Create, Contribute\***

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# References

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- NRC Vision and Strategy (ML16356A670)
- Implementation Action Plans (IAPs) (ML17165A069 and ML17164A173)
- Regulatory Review Roadmap including prototype guidance (ML17312B567)
- RG 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors" (ML17325A611)
- SECY-18-0011, "Advanced Reactor Program Status" (ML17334B217)
- SECY-19-0009, "Advanced Reactor Program Status" (ML18346A075)
- SECY-18-0076, "Option and Recommendations for Physical Security for Advanced Reactors" (ML18052B032)
- SECY-18-0096, "Functional Containment Performance" (ML18114A546)
- SECY-18-0113, "Proposed Rule: Emergency Preparedness for Small Modular Reactors and other New Technologies," (ML18134A086)
- NEI-18-04, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," (ML18271A172)
- DG 1353, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications," (ML18264A093)